POLYCRYSTALLINE PRESOLAR SPINEL IDENTIFIED IN THE DOMINION RANGE 08006 CO3.0 CHONDRITE.

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Introduction: Presolar circumstellar dust grains are preserved inside of primitive meteorites, and their detailed study can provide information on stellar evolution, thermodynamic conditions of grain condensation, as well as on grain transportation through the interstellar medium, and solar-system processes. Many types of circumstellar grains have been identified in primitive meteorites [1]. Among those are oxide grains, which are predicted by equilibrium calculations to condense in the outflows of stellar environments [2], and emission features between 9 to 13 μm from O-rich stars have been attributed to grains of Al_2O_3 and $MgAl_2O_4$ [3,4]. We have reported previously on oxide grains derived from acid-residues and identified *in situ* [5-8]. Here report on a circumstellar spinel identified *in situ* within the DOM 08006 CO 3.0 chondrite.

Sample and Analytical Methods: A petrographic thin section of DOM 08006 was examined with the Washington University (WUSTL) NanoSIMS 50 to search for presolar grains [8]. C- and O-raster ion imaging was carried out on several fine-grained areas of the meteorite using standard procedures [7, 8]. Following NanoSIMS measurements, we used the WUSTL Auger Nanoprobe to acquire elemental distribution maps of isotopically anomalous regions. Among the grains identified, we chose grain DOM-9 for detailed analysis using transmission electron microscopy (TEM). We created an electron-transparent cross section of the region with the FEI Helios focused-ion-beam scanning-electron microscope (FIB-SEM) located at the Lunar and Planetary Laboratory (LPL). We used previously described FIB techniques, including the deposition of fiducial markers prior to ion milling [6,9]. The FIB section was analyzed using the 200 keV Hitachi HF5000 TEM newly installed at LPL. The HF5000 is equipped with a cold-field emission gun, dual energy-dispersive X-ray spectrometers (EDS) providing a large solid-angle (~2.0 sr), and spherical-aberration corrector for scanning TEM (STEM) imaging.

Results and Discussion: NanoSIMS analysis shows that DOM-9 has $^{17}O/^{16}O = (5.3 \pm 0.2) \times 10^{-4}$; $^{18}O/^{16}O = (1.83 \pm 0.04) \times 10^{-3}$, placing it within the Group 1 field, as defined by [10], and is consistent with an origin from an RGB star undergoing first dredge-up whose initial mass was approximately $1.3M_{\odot}$ with a solar metallicity. The O-isotopic anomaly ('hotspot') measures approximately 230 nm × 230 nm, and Auger maps show that it contains Mg, Al, and O. Secondary electron imaging in the FIB reveals a horseshoe-shaped grain that Auger maps reveal contains Mg, Si, and O. We deposited fiducial markers of Pt onto and adjacent to the hotspot prior to deposition of the final 3-μm C-capping layer to guide in situ thinning. STEM images reveal an ~1.5 μm wide grain beneath the Pt fiducial marker. High-angle annular-dark-field imaging shows that part of this grain contains an irregularly shaped 500-nm domain with relatively brighter contrast, suggesting higher average atomic number than the host. The bulk of the domain is circular in morphology but has a thinner ~200-nm wide lobe that extends from one side to the surface capping layer. EDS mapping reveals that the domain contains Mg, Al, Cr, and O with minor Fe and is hosted in a grain composed of Mg, Si, Ca, Cr, minor Fe. Selected-area diffraction (SAED) patterns and TEM imaging show that the Mg-Al-Cr-Fe-O bearing grain is polycrystalline, and measurements indicate consistency with the spinel structure. An SAED pattern acquired from the Si-bearing host grain suggest that at least parts of it lack long-range order, and so we tentatively refer to it as a Mg-silicate. Comparison of the TEM data with the NanoSIMS images and Auger compositional maps show that only the spinel grain is presolar; the surrounding silicate grain has an O isotopic composition within solar values. Previous studies have argued that Cr- and Fe-bearing presolar spinels from residue samples are inconsistent with equilibrium predictions [5]. The Cr-rich composition of DOM-9 appears to be qualitatively consistent with these previous observations, but such a conclusion requires quantitative analysis, which we plan to do. This observation suggests the possible occurrence and survival of presolar grains within the region of the solar nebula where condensation took place and perhaps served as nucleation sites for such materials.

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